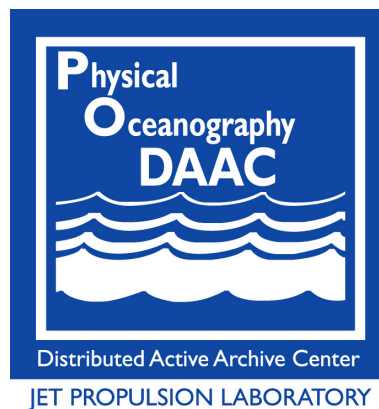# Physical Oceanography Distributed Active Archive Center (PO.DAAC)

QuikSCAT Level 3 Near-Coast Wind and Stress Fields with Enhanced Coastal Coverage (OSU): US West Coast Region

Guide Document

6 June 2013

Version 1.2

Jet Propulsion Laboratory
Pasadena, California

Table of Contents:

1. Abstract:

This ocean vector wind (OVW) data product is provided as a service to the ocean and atmosphere research communities. It alleviates the data download, processing and storage burden from researchers who would otherwise have to potentially download and process hundreds of gigabytes of in-swath observations. This OVW product provides high spatial resolution (0.1° latitude by 0.1° longitude) wind fields derived from approximately 124 months (July 1999 – November 2009) of QuikSCAT scatterometer observations over the California Current System (CCS). It is unique in that it contains a narrower land mask than QuikSCAT observations processed using standard methods, which allows for wind retrievals closer to the coast where gradients in the wind field are dynamically important for ocean circulation. Development of the empirical land mask used to generate these coastal wind vectors was funded by NASA in the Research Opportunities in Space and Earth Science program (ROSES), contract number 1283976. Additional support was provided by Award NA03NES4400001 and NA08NES4400013 to the Oregon State University (OSU) Cooperative Institute for Oceanographic Satellite Studies (CIOSS) from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. This product includes the following 12 wind variables: wind speed, wind speed squared, wind speed cubed, zonal and meridional wind components, wind curl and divergence, wind stress magnitude, zonal and meridional wind stress components, and wind stress curl and divergence.

2. Investigators:

Principal Investigator:
Dr. Barry Vanhoff
Oregon State University
Corvallis, Oregon

Co-Investigators:
Dr. Michael Freilich
Dr. Ted Strub

User Guide Authors:
Mr. Craig Risien (Oregon State University)
Dr. Barry Vanhoff (Oregon State University)
Mr. David F. Moroni (Jet Propulsion Laboratory, California Institute of Technology)

3. Background:

This data set is unique for 2 reasons:

1) It uses a new empirically derived land mask that allows for wind retrievals within 5 - 20 km of land, a region where strong wind gradients are dynamically important for ocean circulation. Currently this data set only includes winds along the US West Coast; additional regions will be added as they become available.

2) It eliminates the need for researchers to download and grid QuikSCAT data themselves as it provides approximately 10 years of gridded data for 12 variables including wind speed, wind speed squared, wind speed cubed, zonal and meridional wind components, wind curl (vorticity) and divergence, wind stress magnitude, zonal and meridional wind stress components, and wind stress curl and divergence.

4. Processing Methodology:

This dataset was formed using a shoreward extension of the current QuikSCAT Level 2B 12.5km Ocean Wind Vectors. The newer coastal wind vectors (described below) along with the science quality L2B wind vectors were combined and then interpolated and smoothed onto a 0.1 degree grid using a locally weighted scatterplot smoother (LOESS) with a half-span (radius) of 40km. All derivative fields in this data set were generated by coefficients derived from the two-dimensional 2nd order polynomial surface as estimated by the smoother.

4.1 Generating Coastal Wind Vectors

Coastal wind vectors were generated by applying wind retrieval to the backscatter measurements (i.e., sigma0) using a land mask that is narrower than the 20km mask used in the standard (science) processing. The footprint of the sigma0 slices that are used in standard 12.5km wind retrievals is approximately 25km in azimuth by 2-10 km in the look (or range) direction; to avoid including contaminated backscatter measurements in wind retrieval, any sigma0 value that is either partially over land or close to land (because of sidelobes in the antenna radiation pattern) is flagged and therefore avoided. Since the SeaWinds instrument uses a rotating pencil beam antenna, the orientation of each slice may lead to useable sigma0 that are closer to land than the 20km one-size-fits-all land mask would allow.

The narrow land mask used here was generated based on the following hypothesis: at a fixed viewing geometry, sigma0 will have a larger time-variability over the ocean than over land. Sigma0 variability over the ocean is a function of the underlying wind field, whereas sigma0 variability over land is mainly a function of changes in reflectivity (recent rain/snow) and atmospheric effects. Figure 1 shows maps of sigma0 variability made using 9 years of QuikSCAT data for all measurements that have the following viewing geometry: antenna azimuth of 135 (upper) and 45 (lower) degrees (from ascending passes only) and use the inner (H-pol) antenna. In addition, Figure 1 shows the approximate shape, size, and orientation of the sigma0 slices that were used to generate the maps, and the elevation as provided by the GTOPO30 database [12]. While it is true that coastal topography influences the radar backscatter, it is important to understand that it is variability in the backscatter (or lack thereof) that indicates whether the measurement location is usable for a given satellite viewing geometry. The standard deviation at each point was calculated using all sigma0 measurements of similar viewing geometry within a small fixed radius of the grid point. As can be seen from Figure 1, at a fixed location near land the orientation of a sigma0 slice has a profound effect on whether it is considered contaminated (low variability) or uncontaminated (high variability). A median filter was applied to the raw variability maps to aide in finding the new geometry dependent land mask. Figure 2 shows an example of how the variability of horizontally and vertically polarized backscatter measurements change as one moves offshore; the long-axis of the sigma0 slices are oriented parallel to the coast for the purposes of this figure. The value of variability used to separate contaminated regions from uncontaminated regions is 4 dB. This value is empirical in nature and was derived by first

looking at histograms of sigma0 variability for all measurements within 50km of land. Figure 1 shows that the regions where the new empirical mask is widest (in black) are approximately 20 km offshore, which is equal to the one-size-fits-all mask used in the standard processing.

The QuikSCAT processing used to generate the science product was modified to allow for use with the new empirical geometry-dependent land mask. The Level 2A processor (which converts time-ordered L1B sigma0 data to space-ordered composite L2A data) and the Level 2B processor (which performs wind retrieval on the spatially ordered L2A data) were combined to allow for direct L1B to L2B wind retrievals. In order to minimize the amount of time needed to do retrievals, winds are only retrieved shoreward of 50km along coastlines for which the new empirical land mask has been generated. Similar to the processing done at JPL, this is done on a rev-by-rev basis. These retrievals are then combined (rev by rev) with the science product and ambiguity removal is performed on the paired dataset.
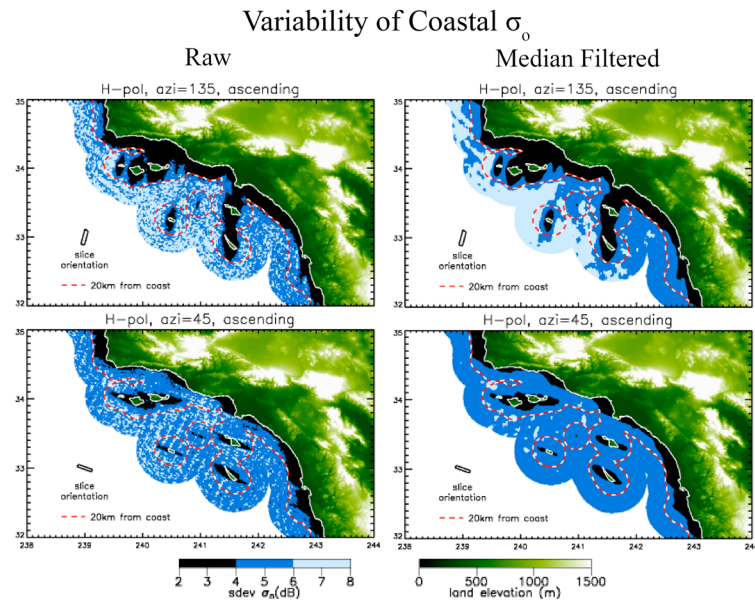

Figure 1 Maps of radar backscatter (sigma0) variability over a 9-year data record at multiple viewing geometries on the GTOPO30 1/120th degree grid. The red dashed line indicates a distance of 20 km from the coast.
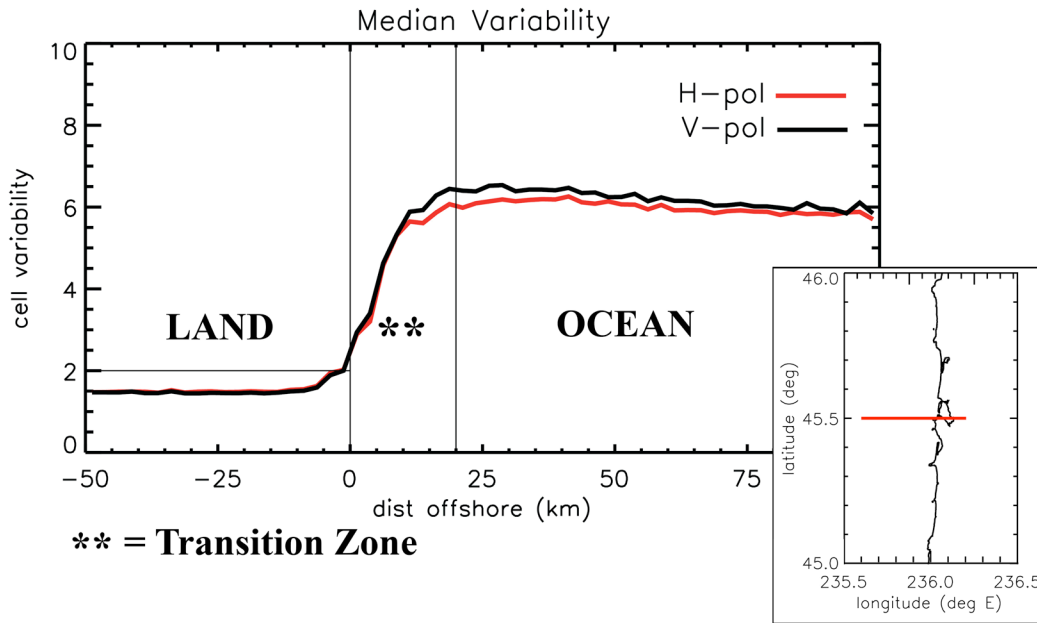
Figure 2 An example of how the variability of horizontally and vertically polarized backscatter measurements change as one moves offshore; the long axis of the slices used in this calculation are approximately parallel to the coastline.

A few important notes about this process:

1) "Ambiguity removal" is the process by which the multiple possible wind vectors generated by the wind retrieval algorithm are filtered to produce a single "selected" wind vector. The ambiguity removal algorithm used for this product is identical to the one used on the L2B product, which is a multi-pass median filter initialized using model winds from NCEP [11]. While the L2B product utilizes a "coastal flag" which restricts the influence of the nearest-to-land (~20 km) wind vectors on its neighboring wind vector cells, this data product removes the coastal flag from *all* retrieved winds. This procedure assumes that most of the land contamination is removed prior to wind retrieval by virtue of the new land mask. While there may still be an occasional land-contaminated wind vector, it should be noted that the median filter algorithm used in ambiguity removal is not sensitive to an occasional outlier [11].

2) There is no rain flagging in the 12.5 km L2B wind product shoreward of ~30 km, therefore these data should be used with caution.

4.2 Interpolating/smoothing onto grid

Interpolating the data fields onto the 0.1 degree grid was done using a locally weighted scatterplot smoother (LOESS) with a half-span of 40km [2,3]. The Level 2B wind vectors were flagged for rain (where available) and zonal and meridional components of speed

and stress (using a modified Large and Pond algorithm [4]) were generated prior to the interpolation process. Interpolated values of speed and stress magnitude were calculated from the LOESS 2D polynomial fit; speed and stress components were scaled appropriately to ensure vector magnitudes were self consistent. Derivative values of the speed and stress components were calculated from the coefficients of the LOESS 2D polynomial fit.

Source datasets include: SeaWinds on QuikSCAT Level 2B Ocean Wind Vectors in 12.5km Slice Composites (PODAAC-QSX12-L2B00), QuikSCAT Level 1B time-ordered backscatter (Sigma0) measurements (PODAAC-QSXXX-L1B02), and OSU empirical geometry-dependent land mask.

Ancillary datasets needed for wind retrieval and ambiguity removal include the geophysical model function (GMF) table and NCEP model winds.
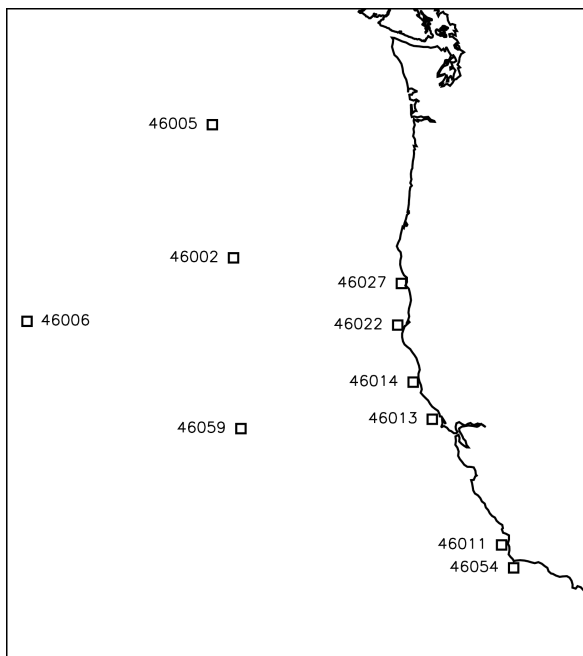
5. Calibration and Validation:

Figure 3 The locations of NDBC buoys used for the initial validation analysis. Six are "coastal" and four are "offshore."

To quantify the usefulness of winds retrieved using the new landmask, comparisons were made to a set of six coastal NDBC buoys along the US West Coast; as a baseline, four offshore buoys were also compared (Figure 3). The collocation criterion includes all QuikSCAT wind vectors that fall within 25 km and 30 minutes of the NDBC buoy measurements. Table 1 shows that, for the four offshore buoys (listed first), the speed RMS (SRMS) is 0.9-1.1 m/s with a corresponding directional-difference RMS (DRMS) of ~22-24 degrees (these directional differences were edited for values that were greater than 90 degrees [5,6]). Speed correlations are all greater than 0.96. For the coastal buoys, the speed and directional differences are somewhat higher and the speed correlations are as low as 0.90. Vectors correlations (VC) for these collocated data sets are greater than 1.66 for the offshore buoys, while the coastal buoys have vector correlations as low as 1.04. (Note, a perfect VC value is 2.0 [7]). Although low VC values can be caused by QuikSCAT winds that are not representative of the underlying true wind conditions, they may also be caused by a lack

of true variability within the wind field ([5,8]).

Table 1 NDBC buoy lats and lons, number of collocations, distance from land, vector and canonical correlations, speed and direction RMS differences, and speed correlations. Buoys within 25 km of land are considered as "coastal"; remaining buoys are in the "offshore" group.

Buoy	Lon	Lat	Npts	Dist	SRMS	DRMS	CORR	VC	CC1	CC2
46002	229.74	42.53	8215	>99 km	0.9 m/s	23.8 deg	0.96	1.69	0.93	0.76
46005	229.00	46.08	8081	>99	1.0	22.4	0.96	1.73	0.93	0.81
46006	222.51	40.84	5272	>99	1.1	22.2	0.97	1.76	0.92	0.84
46059	230.00	37.98	9650	>99	0.9	24.3	0.96	1.66	0.94	0.73
46011	239.13	34.88	4604	21	1.3	29.4	0.92	1.20	0.88	0.32
46013	236.70	38.23	6671	23	1.5	28.7	0.94	1.23	0.91	0.32
46014	236.03	39.22	4042	20	2.1	30.7	0.90	1.14	0.91	0.23
46022	235.49	40.74	4421	22	1.8	35.6	0.90	1.21	0.90	0.30
46027	235.62	41.85	2635	17	2.6	35.6	0.90	1.20	0.88	0.32
46054	239.55	34.27	4871	17	1.7	29.0	0.91	1.04	0.88	0.16

To investigate the cause of the lower VC values, Figure 4 shows a 2-D histogram of zonal- and meridional-wind components for NDBC buoy 46013 and the corresponding QuikSCAT collocations. Winds at this location blow in a predominantly alongshore, southeastward direction. Crosby et. al. [7] show that the vector correlation is equal to the sum of the individual canonical correlations (see also [9,10]). For the vector correlation of two 2-dimensional vector quantities there are two canonical correlations (CC1 and CC2), each associated with a canonical direction. The first (and by definition largest) canonical correlation for all of the offshore buoys is between 0.92-0.94, and the second (smaller) canonical correlation is between 0.73-0.84. For the coastal buoys, CC1 drops slightly to 0.88-0.91, and CC2 is quite a bit lower than offshore at 0.16-0.32. The large CC1 indicates that there is a high correlation between the alongshore component of the QuikSCAT-NDBC wind vectors. Assuming that vector wind component errors are isotropic, it follows that the low CC2 is an indicator of little true wind variability in the offshore direction. This suggests that the "signal-to-noise ratio" in the alongshore direction is larger than in the cross-shore direction; this is owing to the variability of the dominant signal, rather than the noise. Figure 4 also shows the magnitude (and directions) of the first and second canonical correlations as a small cross.
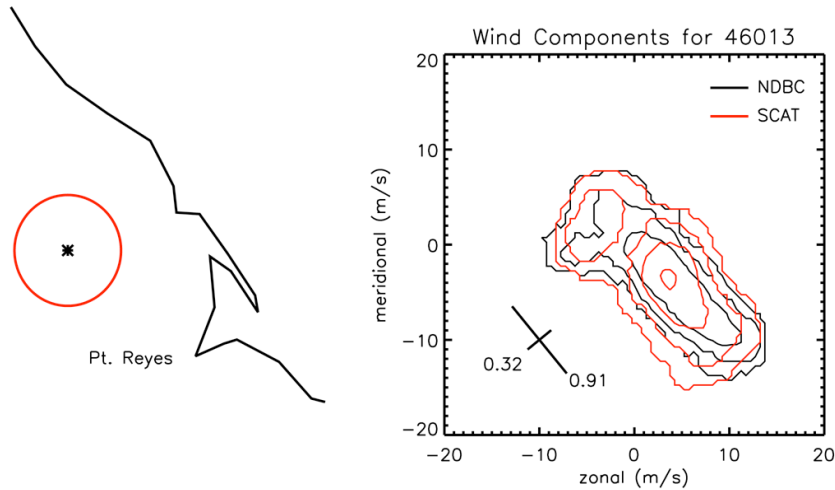
Figure 4 The location of NDBC buoy 46013 (left) and a 2-D histogram (right) of meridional and zonal wind components. NDBC is shown in black with collocated QuikSCAT in red. The small cross represents the first- and second- canonical correlations along with their associated directions.

In addition, the near-coast gridded QuikSCAT wind fields were compared with 25 km and 12.5 km QuikSCAT fields for March through May 2009. Figures 5 and 6 show daily composites of wind speed and direction for the 3 OVW products, the 0.25° JPL data set (derived from the 25 km L2B product; left panels), the 12.5 km JPL data set gridded to a 0.10° grid (center panels) and the 0.10° data set described here (right panels), for April 26 and May 18, 2009, respectively. Clearly visible in the JPL 0.25° (0.10°) fields is the 30 km (20 km) land mask. In contrast, the geometry dependent land mask used in the OSU 0.10° dataset allows for wind retrievals within 5 - 10 km of the Santa Catalina and San Clemente Islands. In addition, the OSU 0.10° data set is also able to better resolve mesoscale flow features such as the expansion fans associated with, for example, Cape Mendocino (Figures 5 and 6 middle panels).

Figure 5 Daily JPL 0.25^{o} (left panels), JPL 0.10^{o} (middle panels) and OSU 0.10^{o} (right panels) composite wind speed and direction fields for 26 April 2009. The top panels show winds over the entire 0.10^{o} data set domain (30-50 ^{o}N, 115-135 ^{o}W). The middle and lower panels show more detailed views of the Cape Mendocino and California Bight regions, respectively. Note the change in dynamic range.
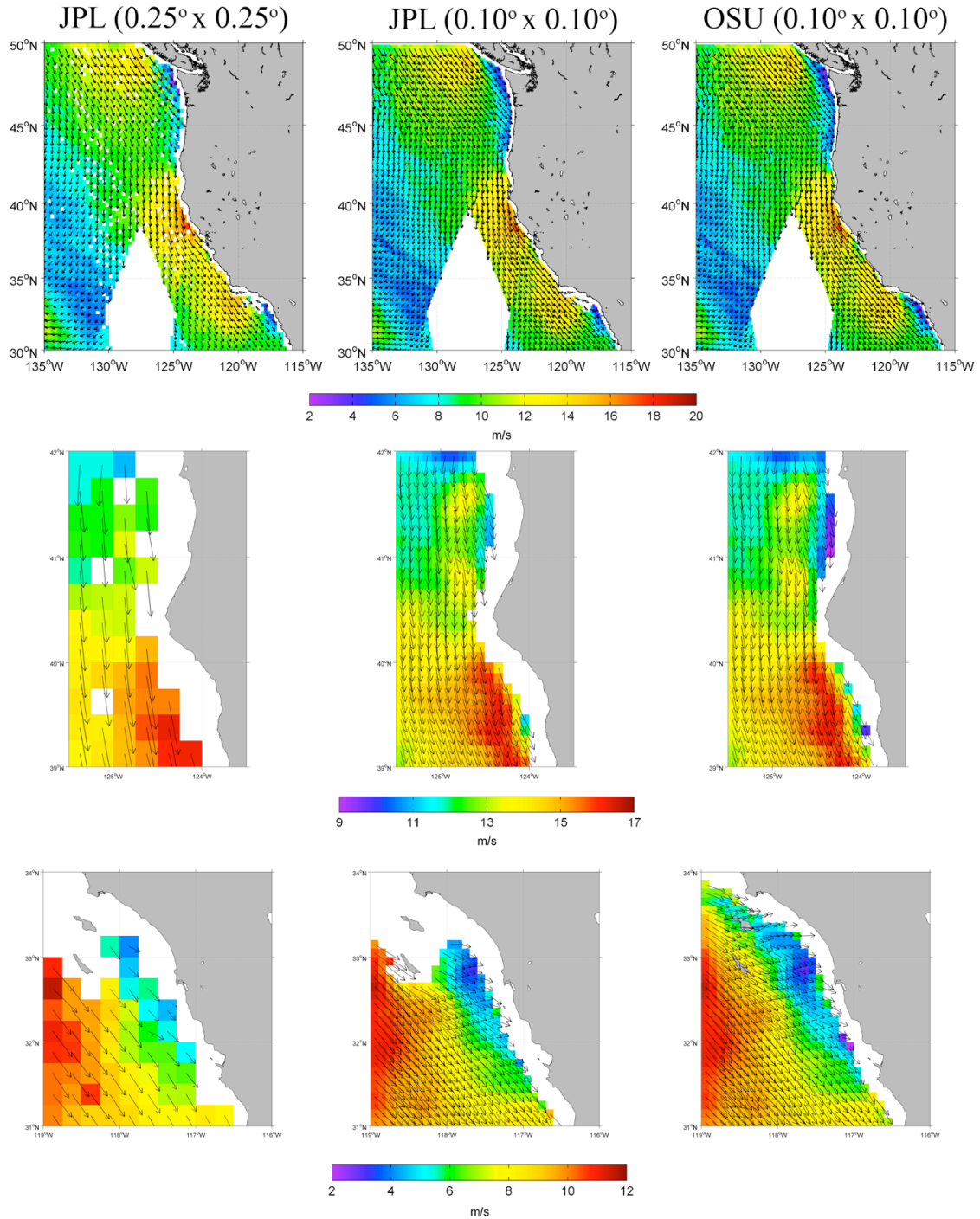
Figure 6 Daily JPL 0.25^o (left panels), JPL 0.10^o (middle panels) and OSU 0.10^o (right panels) composite wind speed and direction fields for 18 May 2009. The top panels show winds over the entire 0.10^o data set domain (30-50 ^{o}N, 115-135 ^{o}W). The middle and lower panels show more detailed views of the Cape Mendocino and California Bight regions, respectively. Note the change in dynamic range.
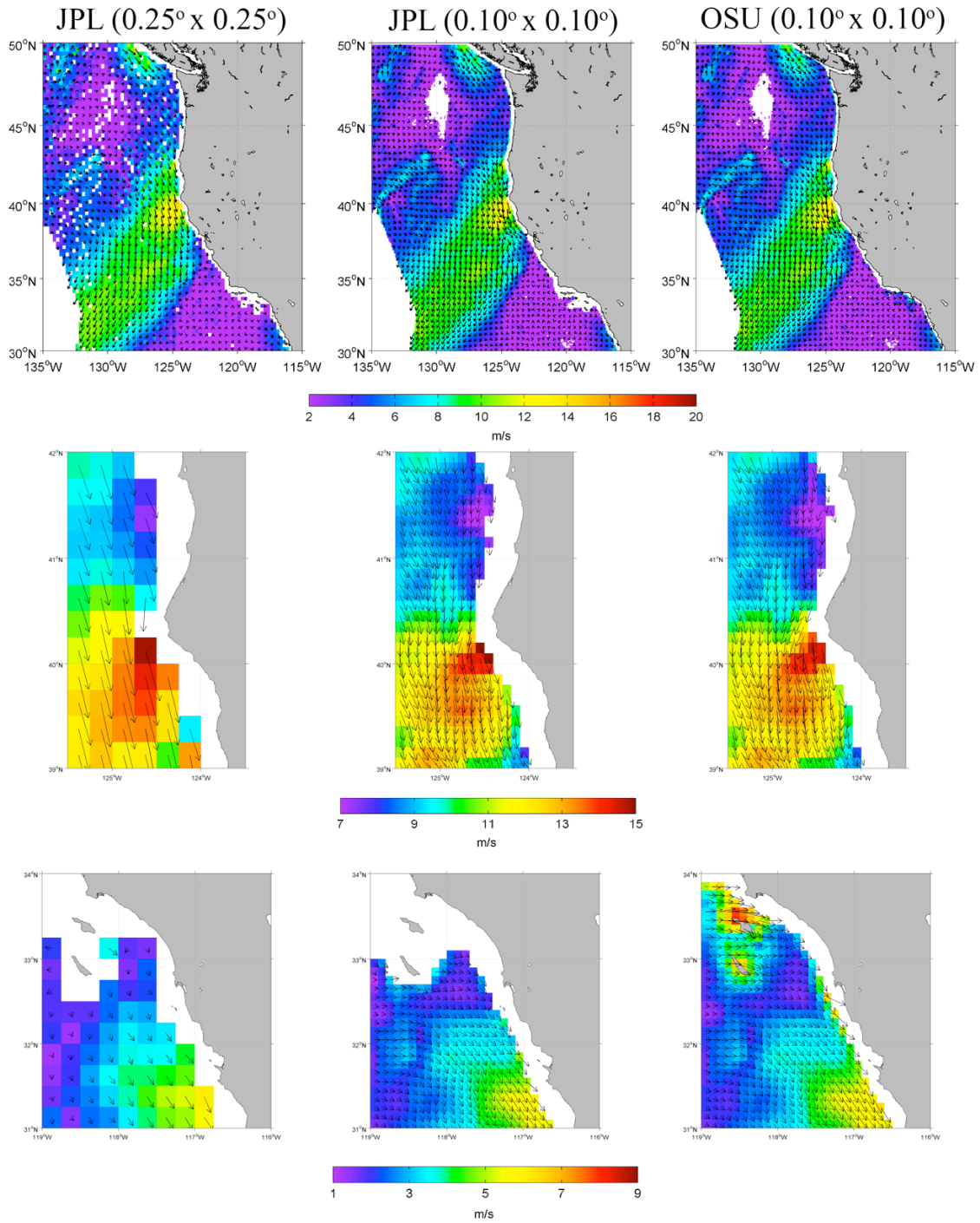
6. Data Set Description:

6.1 Data Set Types

There are currently 12 unique data sets, each of which is consolidated into 12 unique files, which contain approximately 124 months (20 July 1999 – 21 November 2009) of gridded QuikSCAT retrievals and derived parameters. Each data set is unique in that they each contain a singular QuikSCAT-derived variable. Hence, the 12 unique datasets account for 12 combined variables, which are: wind speed, wind speed squared, wind speed cubed, zonal and meridional wind components, wind curl and divergence, wind stress magnitude, zonal and meridional wind stress components, and wind stress curl and divergence. Each QuikSCAT rev that falls within the latitude and longitude bounds described in the global attributes is individually gridded according to the algorithm described above. Typically there will be at least one "ascending" and one "descending" rev for a given region each day. Factors that influence the number of gridded revs in a particular day are satellite drift, scatterometer swath width, and longitudinal and latitudinal extent that the region covers. For latitudes poleward of ~47 degrees, consecutive QuikSCAT revs will always overlap. Each variable-specific data set is provided in a CF v1.3 compliant NetCDF version 3 file.

The file naming convention is variable_name_YYYYMMDD_HHMMSS.nc, where:

variable_name = a unique, short variable name

YYYY = 4-digit year of the file creation date

MM = the 2-digit month of the file creation date

DD = the 2-digit day of month of the file creation date

HH = the UTC hour of the file creation time

MM = the UTC minute of the file creation time

SS = the UTC second of the file creation time

For example, file qscat_uswc_wspd_20110330_205745.nc contains all 12561 wind speed fields for the period 20 July 1999 – 21 November 2009. The ncdump output for qscat_uswc_wspd_20110330_205745.nc is as follows:

```
dimensions:
    longitude = 200 ;
    latitude = 200 ;
    time = UNLIMITED ; // (12561 currently)
```

```
variables:
     float longitude(longitude) ;
              longitude:units = "degrees_east" ;
              longitude:long_name = "longitude" ;
              longitude:standard_name = "longitude" ;
              longitude:valid_range = 225.f, 245.f ;
     float latitude(latitude) ;
              latitude:units = "degrees_north" ;
              latitude:long_name = "latitude" ;
              latitude:standard_name = "latitude" ;
              latitude:valid_range = 30.f, 50.f ;
     int time(time) ;
              time:units = "seconds since 1999-01-01 0:0:0" ;
              time:long_name = "time" ;
              time:standard_name = "time" ;
              time:calendar = "none" ;
     int rev_number(time) ;
              rev_number:units = "counts" ;
              rev_number:long_name = "revolution_number" ;
              rev_number:valid_range = 430, 54296 ;
     short wind_speed(time, latitude, longitude) ;
              wind_speed:units = "m s-1" ;
              wind_speed:FillValue_ = -32768s ;
              wind_speed:scale_factor = 0.01f ;
              wind_speed:long_name = "wind speed at 10m" ;
              wind_speed:valid_range = 0.f, 50.f ;
              wind_speed:add_offset = 0.f ;
              wind_speed:cell_methods = "time: point" ;
              wind_speed:standard_name = "wind_speed" ;

   // global attributes:
              :title = "QuikSCAT Gridded High Resolution Ocean Surface Wind Speed
Along The US West Coast" ;
              :title_short_name =
"QSCAT_Vanhoff_L3_OW_Speed_US_West_Coast";
              :granule_name = "qscat_uswc_wspd_20110330_205745.nc" ;
              :author = "Barry Vanhoff and Craig Risien
crisien@coas.oregonstate.edu)" ;
              :institution = "OSU/COAS" ;
              :creation_date = "2011-03-30" ;
              :creation_time = "20:57:45" ;
              :start_date = "1999-07-20" ;
              :start_time = "02:26:00" ;
              :end_date = "2009-11-21" ;
              :end_time = "14:34:00" ;
              :latitude_resolution = "0.1 degrees" ;
```

:longitude_resolution = "0.1 degrees" ;
:version_id = "1.0" ;
:history = "First created as version 1.0 using QuikSCAT L1B and L2B 12.5 km data sets provided by the QuikSCAT Project and distributed through the PO.DAAC." ;
:source = "QuikSCAT" ;
:processing_level = "L3" ;
:Conventions = "CF-1.3" ;
:comments = "This file was created using IDL Version 7.0 (linux x86_64 m64). (c) 2007, ITT Visual Information Solutions" ;

6.2 Variable Types

<p align="center">Table 2 Dataset Variable Description</p>

Name	Number Type	Scale Factor	Offset	Missing Value	Description
Time	double	0.0	0.0	N/A	seconds since 1999-01-01
rev_number	short	0.0	0.0	N/A	counts
Longitude	float	0.0	0.0	N/A	longitude (deg E)
Latitude	float	0.0	0.0	N/A	latitude (deg N)
wind_speed	short	0.01	0.0	-32768	scalar averaged wind speed at 10m (m/s)
wind_speed_squared	long	0.01	0.0	-2147483648	scalar averaged wind speed squared at 10m (m^2/s^2)
wind_speed_cubed	long	0.01	0.0	-2147483648	scalar averaged wind speed cubed at 10m (m^3/s^3)

eastward_wind	short	0.01	0.0	-32768	zonal wind component at 10m (m/s)
northward_wind	short	0.01	0.0	-32768	meridional wind component at 10m (m/s)
atmosphere_relative_vorticity	long	1e-7	0.0	-2147483648	wind curl at 10m (s^-1)
divergence_of_wind	long	1e-7	0.0	-2147483648	wind divergence at 10m (s^-1)
magnitude_of_surface_downward_stress	short	0.0005	0.0	-32768	scalar averaged wind stress magnitude at 10m (N/ m^2)
surface_downward_eastward_stress	short	0.0005	0.0	-32768	zonal wind stress at 10m (N/ m^2)
surface_downward_northward_stress	short	0.0005	0.0	-32768	meridional wind stress at 10m (N/ m^2)
curl_of_surface_downward_stress	long	2e-9	0.0	-2147483648	wind stress curl at 10m
divergence_of_surface_downward_stress	long	2e-9	0.0	-2147483648	wind stress divergence at 10m

6.3 Grid Description

The dataset described here is on a simple, rectangular grid of 200 columns by 200 rows. Therefore, a grid element spans 0.1 degrees in longitude (20/200) and latitude (20/200). Latitude and longitude coordinates are assigned to each grid element based on its center. The center of the bottom left grid cell is 30.05° North and 225.05° East. The latitude and longitude of the top right grid cell is centered at 49.95° North and 244.95° East.

Table 3 Spatial and Temporal Coverage

Dimension	Name	Size	Range	Spacing
1	Latitude	200	30 to 50 deg	0.1 deg
2	Longitude	200	225 to 245 deg	0.1 deg
3	Time	12561	20/07/1999 to 21/11/2009	asc/des passes

7. Sources of Error:

The user should use caution when making composites of fields from multiple passes; the width of the land mask is variable and will be different depending on satellite viewing geometry. For example, if the mask were narrower for a morning pass than for the following evening pass, combing the two to form a daily composite would result in an unnatural average near the coast, especially if there are large diurnal cycles in that particular region.

Another issue that the user should be aware of is the lack of rain flagging near the coast. The autonomous rain flag used in the 12.5 km QuikSCAT product (and in the author's coastal product) is not calibrated within 30 km of land, thus there will be *some* rain contamination in these gridded fields. Because of the lack of usable rain flags within 30 km of the coast, the rain flag value closest to the coast from the standard processing is applied between that rain flag's location and the coast.

Furthermore, the author took great caution when applying the interpolation scheme (LOESS) near land and at the edge of the swaths. In order to avoid extrapolating into these unsampled regions it is required that there be at least one L2B wind vector within 15 km and at least twenty (20) L2B wind vectors within 40 km of each cell center.

Finally, when interpolating scalar fields using LOESS, it is possible (but rare) that an interpolated value will fall outside the range of the input data used to form the estimate. Thus if the interpolated value of speed, zonal and meridional components of speed, stress, or zonal or meridional components of stress fell outside the range of their input values, all data in the cell are flagged as missing (including values of derivative fields). As with any measurements, there is noise in the raw 12.5 km wind vector measurements; taking spatial derivatives of "noisy" wind data may result in spurious values in the derivative fields. Thus, extreme values of the derivative fields are flagged as missing when they fall outside their valid range.

8. Known Issues:

Before first proceeding in using this dataset for research or other applications, it is strongly encouraged that users examine a sequence of multiple parameter fields for the region and period of interest to ensure sufficient data quality and continuity.

While this dataset is an improvement over other OVW datasets (particularly QuikSCAT) that include an arbitrarily defined land mask, it is worth noting the following issues: a) data fields were produced using a modification of QuikSCAT Version 2 (i.e., previous version) winds, b) median-pass filter ambiguity removal is employed, hence not achieving the potential improvements from "DIRTH" [12], which affect the directional quality of the wind vector and stress data, c) the processing does not incorporate the latest QuikSCAT re-processing improvements (i.e., Version 3 is most recent), d) different model winds (improved compared to Version 2 QuikSCAT L2B) are used in the ambiguity removal process for the entire dataset, and e) there are no usable rain flags within 30 km of the coast (see Section 7: Sources of Error). There are some consequences in light of the above issues, notably: a) the wind vector fields should not be merged with any other existing QuikSCAT dataset, b) there is more inherent structure to the data (in both signal and noise) compared to Version 3 data, and hence wind vectors particularly near the coast may be questionable (see Figure 7), c) data fields are smoother in comparison to the Version 2 data, and d) potentially spurious wind vectors may arise within ~30 km of the coast due to unflagged rain contaminated data and/or residual land reflections.
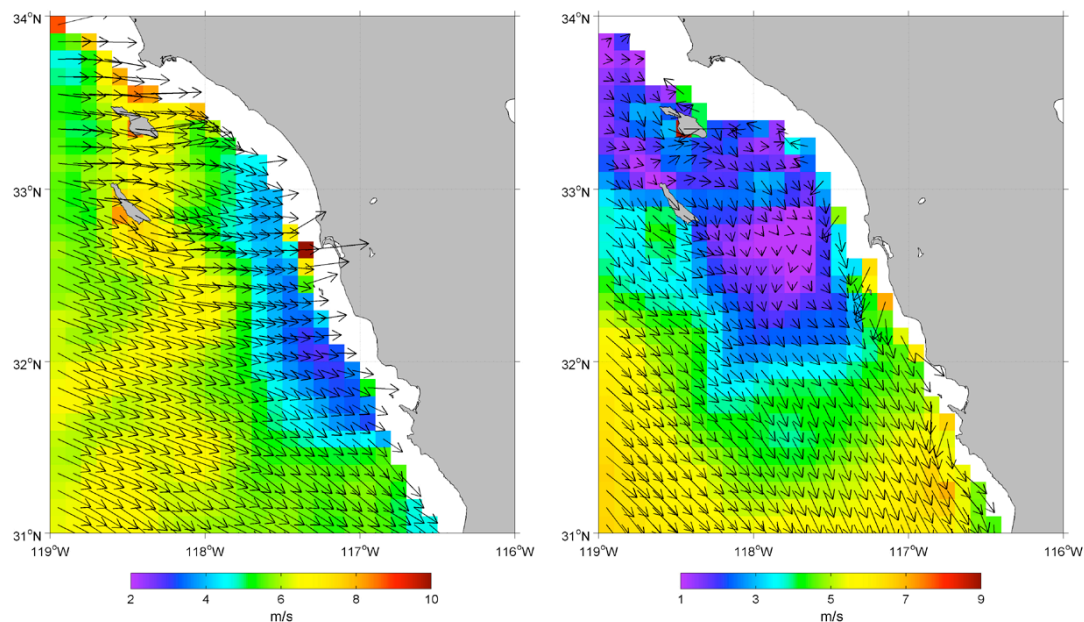

Figure 7 Daily OSU 0.10° x 0.10° composite wind speed and direction fields for 29 March 2009 (left panel) and 13 April 2009 (right panel). Note the potentially spurious wind vectors off San Diego (left panel at 32.82 °N, 117.13 °W) and Santa Catalina Island (right panel at 33.35 °N, 118.33 °W).

As stated previously, the ambiguity removal algorithm is a multi-pass median filter and is insensitive to outliers [11]. Thus contamination is limited to the innermost retrieved wind vectors (ie, closest to land).
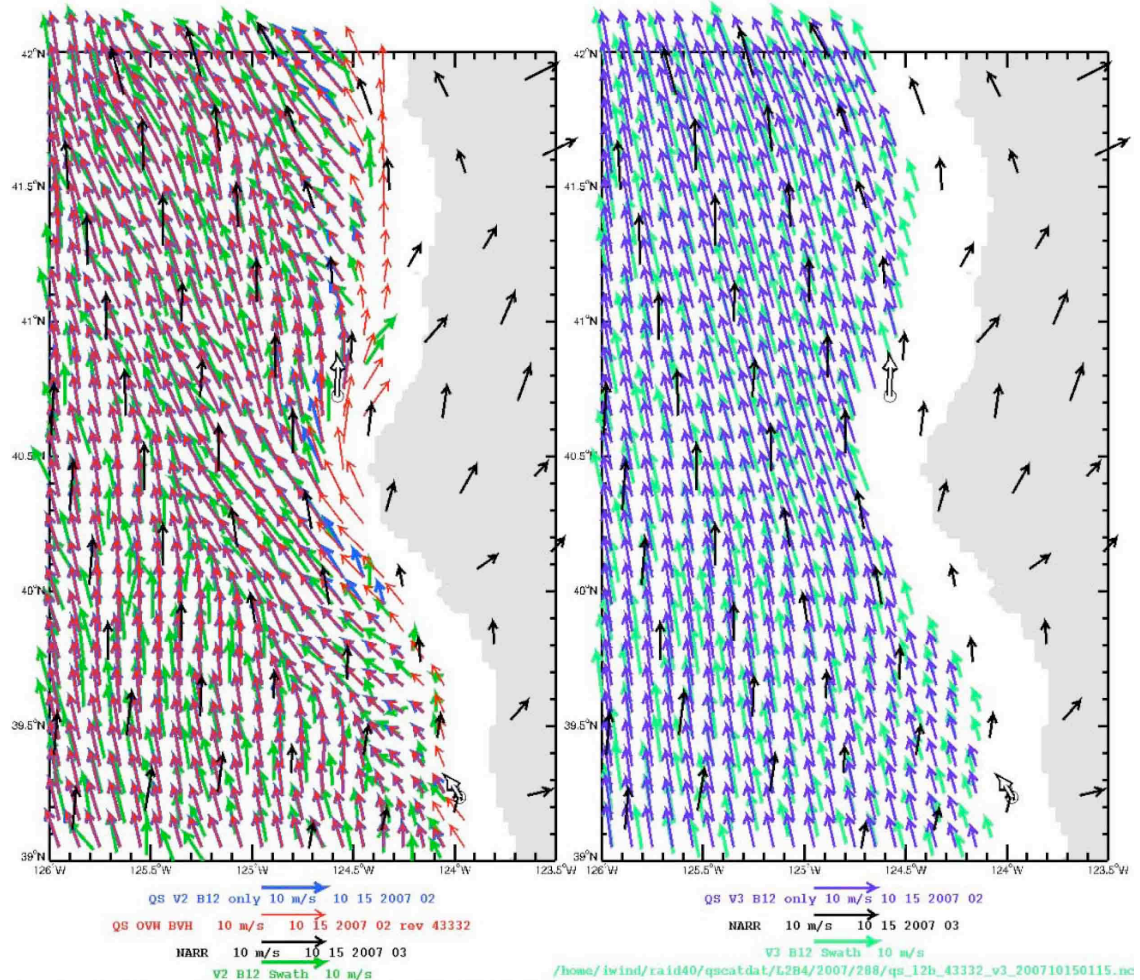

Figure 8. Alternate wind retrievals for October 15, 2007, using Version 2 (left) and Version 3 (right) processing. In both panels, Green Vectors represent winds at their original locations within the swath; Blue Vectors are winds interpolated from their irregular swath locations to a regular 0.1° grid; Red Vectors are winds interpolated to the same 0.1° grid, combining both the new coastal wind retrievals and the original swath retrievals (Version 2). The red vectors sometimes overlay the blue vectors. Black vectors are from the closest (in time) NARR fields of surface winds. NDBC buoy winds at 39.2°N and 40.7°N are also shown.

If potential users of this data set follow our strong recommendation to look at a sequence of individual fields from their region and period of interest, they will find several types of wind fields, as illustrated by Figures 8-10. Figure 8 presents two panels of ocean vector winds for October 15, 2007. The black vectors in both fields are surface winds from the North American Regional Reanalysis (NARR) atmospheric model. The left panel contains three additional vector fields in different colors: the original Version 2 retrievals of the winds at their swath locations are in green; winds interpolated from only these vectors to a standard 0.1° grid are in blue; and winds interpolated to the same grid, but

including new swath vectors retrieved with the empirical land mask are in red. The right panel includes Version 3 vector winds at the original swath locations (green) and winds interpolated to the same 0.1° grid from just those Version 3 swath vectors (blue). Also shown are two vectors representing wind observations within an hour of the satellite data from NDBC Buoy 46022 near 40.7°N and Buoy 46014 near 39.2°N. The buoy winds are in relatively good agreement with the scatterometer measurements.

In this example, winds are poleward throughout the domain, with more structure in the Version 2 field (left, green vectors) than the Version 3 field (right, green vectors). The question that is difficult to answer is whether the structure is real? The Version 3 winds seem too smooth, while the transition between the Version 2 northward winds in the south and the band of winds to the northwest across the middle of the field seems too abrupt. The additional vectors that have been retrieved by the use of the narrower empirical land mask are clearly seen in the red vectors closest to the coast in the northern portion of the field.
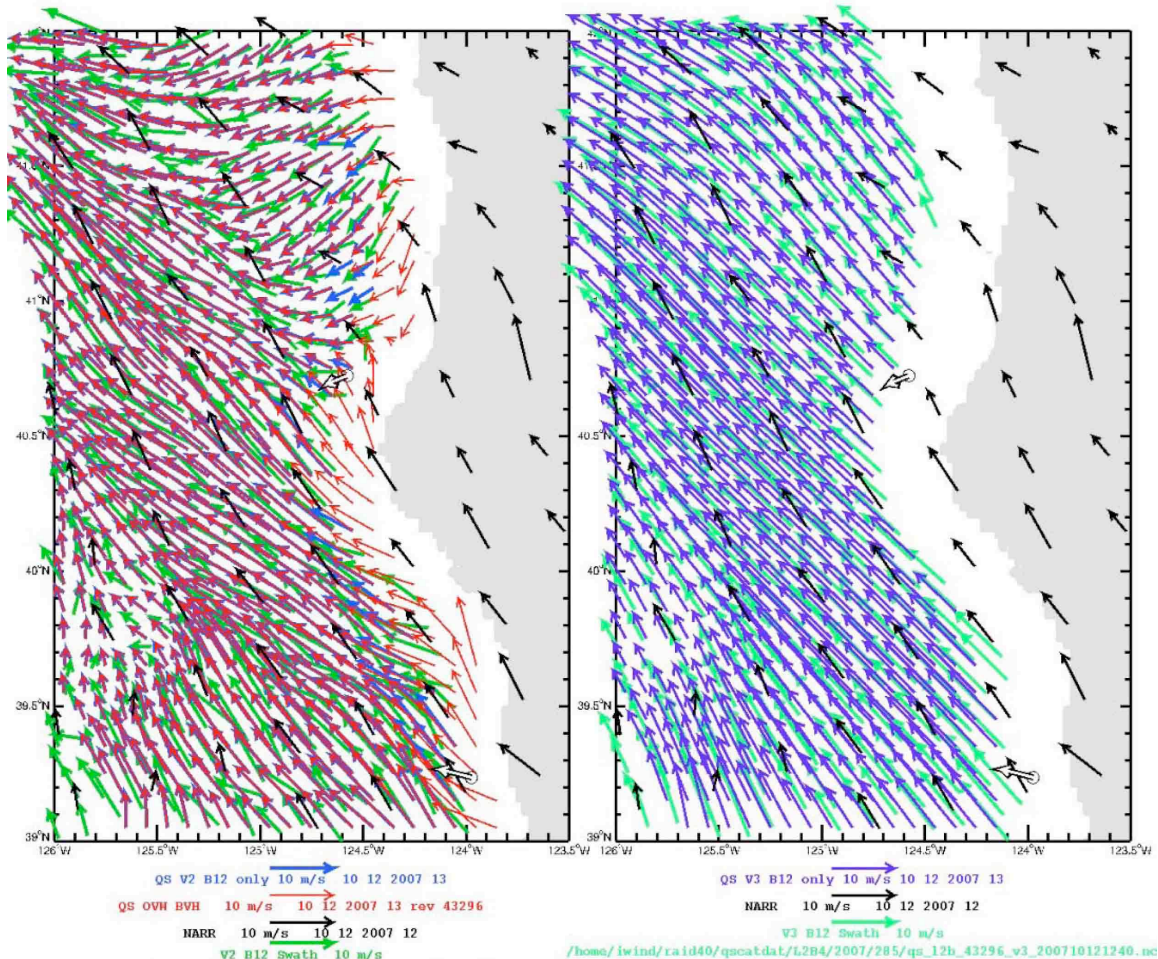

Figure 9. Alternate wind retrievals for October 12, 2007. As in Figure 8.

Figure 9 presents another example of wind fields with additional coverage next to the coast provided by processing with the empirical land mask. In the wind fields produced

with Version 2 processing (left, green vectors), there is a confluence of winds from the north and south, in qualitative agreement with the buoy winds. Winds produced with Version 3 processing (right, green vectors) are again smoother than Version 2 winds, perhaps missing the nature of the converging wind vectors due to over-smoothing. Gridding of the (green) swath data, with (red) and without (blue) the additional coastal vectors includes the differences in the nature of the retrieved swath winds.
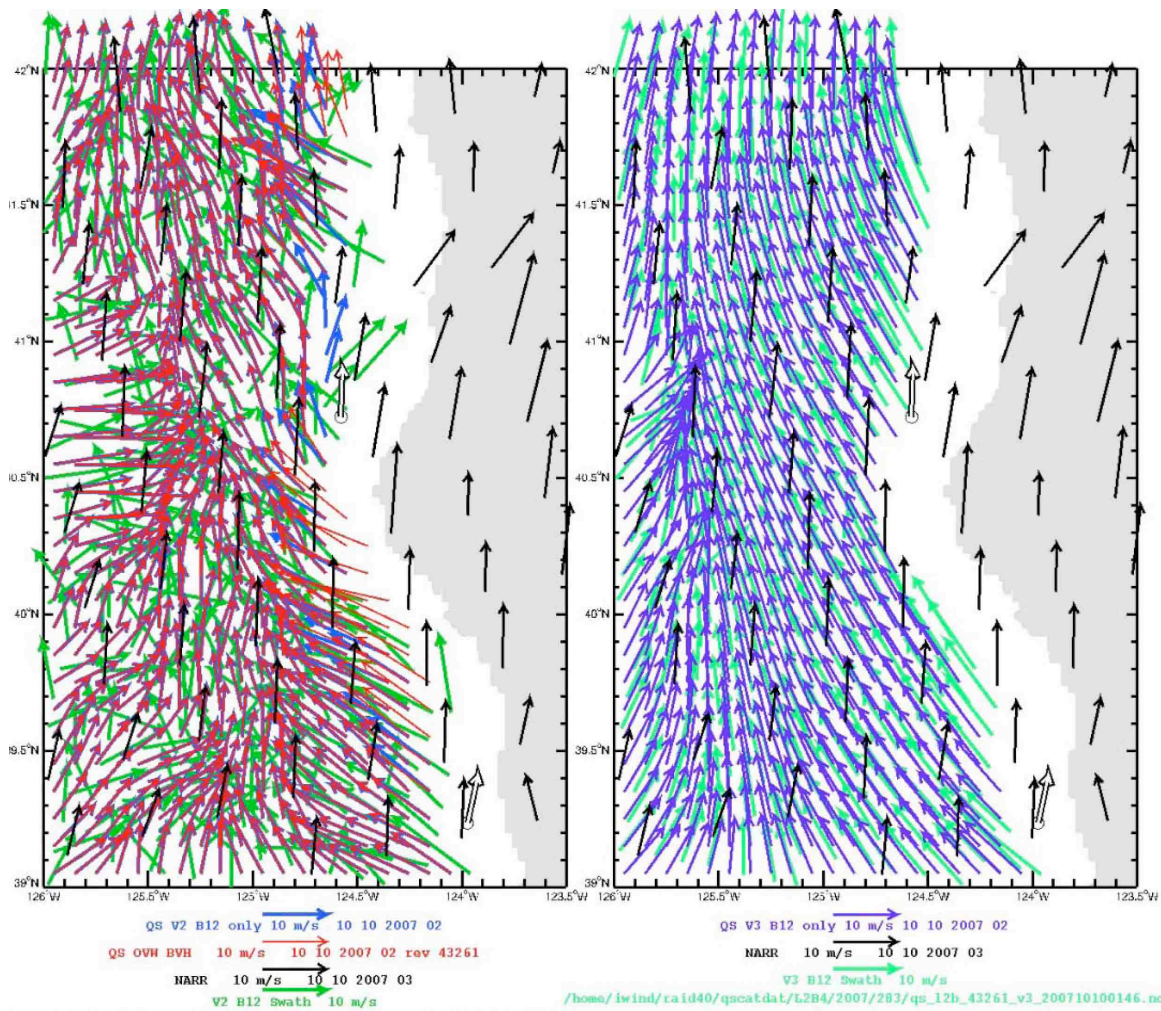

Figure 10. Alternate wind retrievals for October 10, 2007. As in Figure 8.

Figure 10 is an example of the increased noise in some of the Version 2 fields. The green vectors on the left show the noise that is sometimes present due to directional errors in Version 2, especially without the DIRTH processing. The Version 3 winds are (again) smoother than the Version 2 winds. Potential users of this data set should look for examples such as this before computing statistics or performing analysis that could be affected by this noise. Noise in the derivative (curl and divergence) fields will be even greater than the noise in the wind and wind stress fields.

From the above figures, it seems clear that the most optimal processing of scatterometer winds for coastal locations remains a topic for research and future improvement.

Data Gaps

This dataset contains a total of 12561 satellite orbits starting at 20/07/1999 02:26:00 and ending on 21/11/2009 14:34:00. The days that contain missing fields due to satellite outages are listed below. A list of all L2B data gaps greater than 4 seconds in duration is available at http://podaac.jpl.nasa.gov/quikscat/qscat_prob.html.

A list summary of known datagaps for this particular region is shown below:

    19 July 1999: Ascending & Descending
    17 November 1999: Ascending
    18 November 1999: Ascending & Descending
    02 January 2000: Ascending & Descending
    17 November 2000: Ascending & Descending
    18 November 2000: Ascending & Descending
    12 May 2001: Ascending & Descending
    13 May 2001: Ascending & Descending
    14 May 2001: Ascending & Descending
    07 July 2001: Ascending & Descending
    08 July 2001: Ascending & Descending
    18 November 2001: Ascending & Descending
    19 November 2001: Ascending & Descending
    20 March 2002: Ascending & Descending
    20 August 2002: Ascending & Descending
    19 November 2002: Ascending & Descending
    18 December 2003: Ascending & Descending
    16 July 2006: Ascending & Descending
    17 July 2006: Ascending & Descending
    12 November 2006: Descending
    07 December 2007: Ascending & Descending
    25 June 2008: Ascending & Descending
    26 November 2008: Ascending & Descending
    27 November 2008: Ascending & Descending
    28 November 2008: Ascending & Descending
    06 December 2008: Ascending
    04 September 2009: Ascending & Descending
    05 September 2009: Ascending & Descending

9. Read Software:

Open source software tools for reading data sets are presently available in IDL. This software is meant to provide very basic reading capability and does not provide any direct way to plot or visualize the data. Read software from other languages (including C, FORTRAN, and MATLAB) will be made available at a later time.

Check the FTP site for read software through our new Web Portal link provided in the next section.

10. Data Access:

Obtaining Data:

The data, read software, and documentation are freely available for public download via anonymous FTP and OPeNDAP. For immediate access, please visit:
http://podaac-www.jpl.nasa.gov/dataset/QSCAT_OSUCOAS_L3_OW_USWestCoast

All data granules are compressed using the industry standard GNU Zip compression utility. To learn more about the GNU compression utility, please visit the GZIP home page: http://www.gzip.org/.

For information on all other ocean data products available at PO.DAAC, please visit our new Web Portal:
http://podaac-www.jpl.nasa.gov/

For general news, announcements, and information on all other PO.DAAC data products, please visit the PO.DAAC home page: http://podaac-www.jpl.nasa.gov/.

Contact Information:

Questions and comments concerning this data product should be directed to the Physical Oceanography Distributed Active Archive Center (PO.DAAC) at the NASA Jet Propulsion Laboratory (JPL). Please note that email is always the preferred method of communication.

E-Mail: podaac@podaac.jpl.nasa.gov

Mail: PO.DAAC User Services Office
            Jet Propulsion Laboratory
            M/S T1721-202
            4800 Oak Grove Drive
            Pasadena, CA 91109

11. References:

[1]   Vanhoff B.A., C.M. Risien, P.T. Strub, D.G. Foley and D.B. Chelton. A High Resolution Ocean Vector Wind Product for the California Current System from 10 Years of QuikSCAT Scatterometer Data. Eastern Pacific Ocean Conference, September 2009. Symposium abstracts.

[2]   Cleveland, W.S. (1979) "Robust Locally Weighted Regression and Smoothing Scatterplots," *Journal of the American Statistical Association*, **74**, 829-836.

[3]   Cleveland, W.S. and Devlin, S.J. (1988) "Locally Weighted Regression: An Approach to Regression Analysis by Local Fitting," *Journal of the American Statistical Association*, **83**, 596-610.

[4]   Large, W. G., J. C. McWilliams, and S. C. Doney, 1994: Oceanic vertical mixing: A review and a model with a nonlocal boundary layer parameterization. Rev. Geophys., 32, 363–403.

[5]   Freilich, M.H. and R.S. Dunbar, 1999: The accuracy of the NSCAT-1 vector winds: comparisons with NDBC buoys. *J. Geophys. Res.,* **104**, 11,231-11,246.

[6]   Freilich, M.H., and B.A. Vanhoff, B.A., 2006: The accuracy of preliminary WindSat vector wind measurements: comparisons with NDBC buoys and QuikSCAT. *IEEE Trans on Geoscience and Remote Sensing*, vol.44, no.3, pp. 622-637.

[7]   Crosby, D., L. Breaker, and W. Gemmill, 1993: A Proposed Definition for Vector Correlation in Geophysics: Theory and Application. *J. Atmos. Oceanic Tec*., 10, 355-367.

[8]   Jelenak, Z., L. N. Connor, and P. S. Chang, 2002: The accuracy of high resolution Winds from QuikSCAT, *in IGARSS 2002: Remote Sensing, Integrating Our View of the Planet: 2002 IEEE International Geoscience and Remote Sensing Symposium*, vol. 2, pp. 732– 734, New York.

[9]   Barnett, T., and R. Preisendorfer, 1987: Origins and Levels of Monthly and Seasonal Forecast Skill for United States Surface Air Temperatures Determined By Canonical Correlation Analysis. *Mon. Wea. Rev*., 115, 1825-1850.

[10]   Bretherton, C.S., C. Smith, and J.M. Wallace, 1992: An Intercomparison of Methods for Finding Coupled Patterns in Climate Data. *J. Climate*, 5, 541-560.

[11]   Shaffer, S.J., R.S. Dunbar, S.V. Hisau, and D.G. Long, 1991: A Median-Filter-Based Ambiguity Removal Algorithm for NSCAT, *IEEE Trans on Geoscience and Remote Sensing*, GE-29, pp. 167-174.

[12]   U.S. Geological Survey (USGS), Global 30-arc second elevation data set, Sioux Falls, South Dakota, Eros Data Center, Department of the Interior, USGS, 1996.

[13]   Stiles, B.W., B. Pollard, and R.S. Dunbar, 2002: Direction interval retrieval with threshold nudging: a method for improving the accuracy of QuikSCAT winds, *IEEE Trans on Geoscience and Remote Sensing*, vol. 40, no. 1, pp. 79-89, doi:10.1109/36.981351.

12. Acronyms:

CC1: First Canonical Correlation
CC2: Second Canonical Correlation
CCS: California Current System
CF: NetCDF Climate and Forecast (CF) Metadata Convention
COAS: College of Oceanic and Atmospheric Sciences
DRMS: Directional Difference RMS
GMF: Geophysical Model Function
LOESS: Locally Weighted Scatterplot Smoother
NetCDF: Network Common Data Form
NOAA: National Oceanic and Atmospheric Administration
OSU: Oregon State University
OVW: Ocean Vector Wind
RMS: Root Mean Square
SRMS: Speed Difference RMS
VC: Vector Correlation

13. Document History

Document Draft Date:

25 August 2010

Document Review Date:

25 August 2010

Document Revision Date:

Initial Release Edit: 23 February 2011

Version 1.1 Edit: 13 April 2011

Version 1.2 Edit: 6 June 2013

Citation:

Document material originally provided by C. Risien and B. Vanhoff on 4 June 2010. First Draft prepared by D. Moroni on 25 August 2010.

This document was approved for Unlimited Release by JPL document review on 25 August 2010.

Minor technical and grammatical edits applied for final release on 23 February 2011.

Version 1.1 Edit: Changed the NetCDF dump example to match most recent file format and attributes, as well as to portray a more generic UNIX dump output. Also changed the missing values as shown in Table 2, which are a result of recent changes in the NetCDF metadata for the FillValue.

Version 1.2 Edit: Updated Section 8, changed from 'Known Problems' to 'Known Issues', with added figures and instances of 'Known Issues' as recently discovered by Dr. Ted Strub and colleagues. PO.DAAC Persistent Identifiers inserted to reference PO.DAAC datasets used by this dataset. Also made minor grammatical and spelling revisions throughout. Substantial revision authorship by Dr. Ted Strub.

Document Location:

ftp://podaac-ftp.jpl.nasa.gov/allData/quikscat/preview/L3/osu_coas/docs/